Working Together for Clean Water

9TH NATIONAL MONITORING CONFERENCE ■ April 28 – May 2, 2014 ■ Cincinnati, Ohio

NWQMC

A high quality cellphone-based portable microscope for streamside data collection

Steven J. Steinberg, Ph.D., GISP

Principal Scientist – Information Management & Analysis

Southern California Coastal Water Research Project

Presentation overview

- Background on SCCWRP
- How this fits into our research direction
- Algae Case study
- Next steps / Future Development

SCCWRP background

- A Joint Powers Agency (JPA) founded in 1969
  - Formed by several government agencies with a common mission that can be better addressed by pooling knowledge and resources
- Address regional monitoring and research needs
  - Cumulative impact assessment
  - Methods development
  - Data integration
- Members include city, county, state, and federal agencies
  - A unique combination of regulators and dischargers

Member organizations

Regulators

- San Diego Regional Water Quality Board
- Santa Ana Regional Water Quality Board
- Los Angeles Regional Water Quality Board
- California State Water Resources Control Board
- U.S. Environmental Protection Agency (Region IX)
- California Ocean Protection Council

Regulated

- City of Los Angeles
- Los Angeles County Sanitation Districts
- Orange County Sanitation District
- City of San Diego Public Utilities Department
- Ventura County Watershed Protection District
- Los Angeles County Flood Control District
- Orange County Public Works
- County of San Diego

Internal Structure

- 44 full-time staff
  - About 40% hold PhDs
  - An additional 30% hold Master's degrees
- Five departments
  - Biogeochemistry
  - Biology
  - Chemistry
  - Information Management & Analysis
  - Toxicology
  - Microbiology

SCCWRP as a unique interface

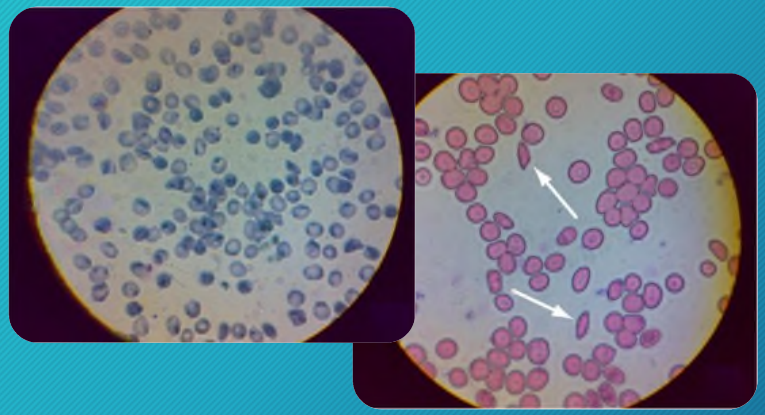
- We are not the only organization exploring development of these sorts of technologies
- We ARE one of the few that can connect all aspects (science, technology and user applications)

Opportunity for in-field microscopy

- SCCWRP is a leader in developing methods and indices for biological assessment approaches for quantification of environmental impacts
- These provide a foundation for establishment of regulatory biological criteria
- California is on the cusp of adopting biocriteria as a means of water quality monitoring using a number of biological indicators:
  - Algae
  - Diatoms
  - Benthic invertebrates

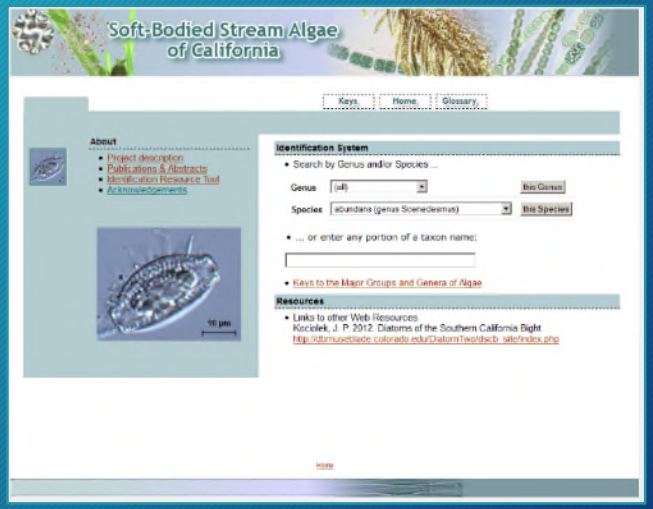
Cell phone microscopes:

- Development has focused on mobile medical imaging and telemedicine applications
- We are working with CellScope developers to apply these technologies to environmental analysis



Why start with algae?

- Provides for field fresh images without preservation or degradation of specimens
- Identification of algae is not as far along as some other areas (greater need)
- Image catalogs for algae are already developed
  - SCCWRP is a world leader helping to develop a web-library for identification of soft-bodied algae in Southern California.

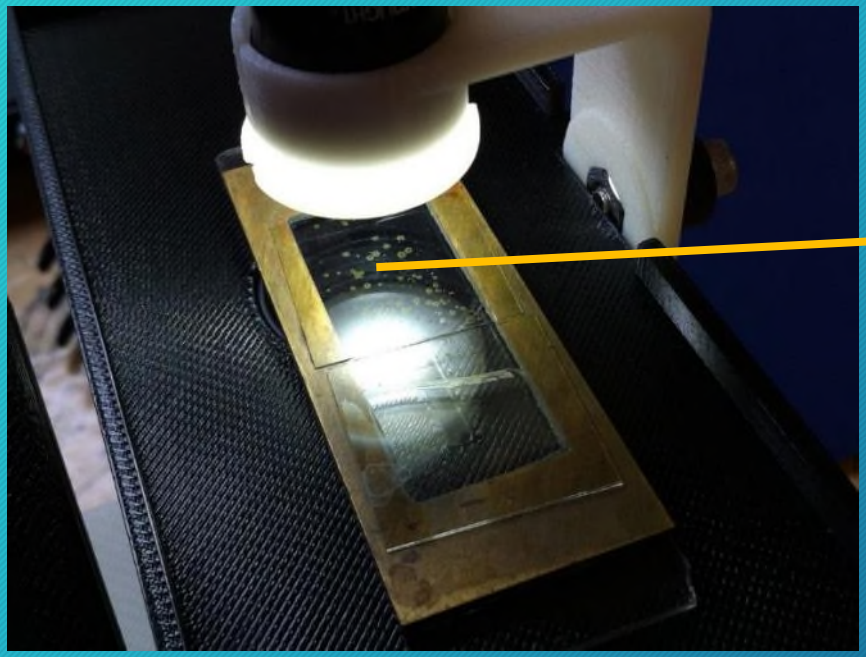


Evaluating the original CellScope for application in phycological studies

Betty Fetscher, Ph.D. with input from Prof. Kalina Manoylov & students of the Summer 2013 Freshwater Algae course at Iowa Lakeside Lab

Example of a specimen with one type of mount
(standard microscope slides also work)

Sedgewick-Rafter counting cell
(accommodates bulky samples)



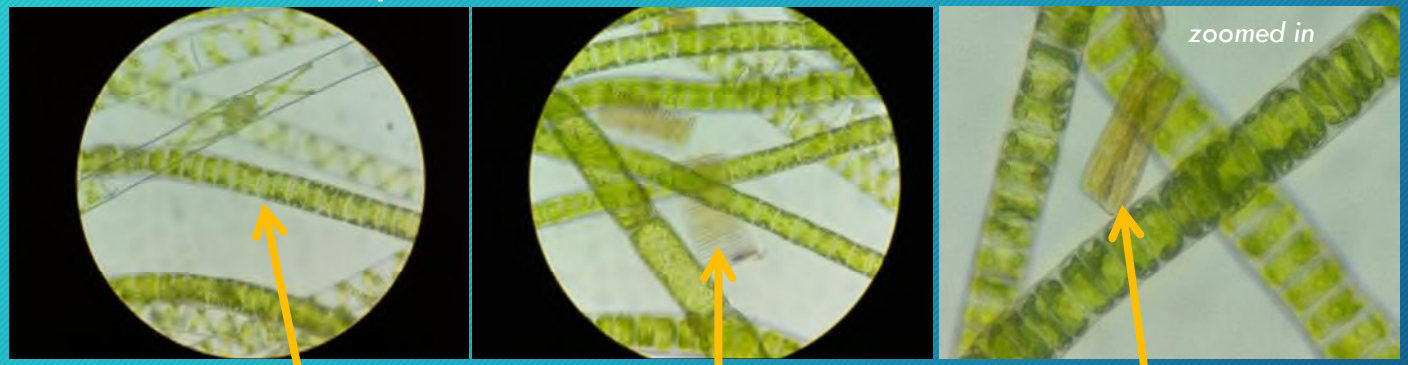
Oblique illumination

Overhead illumination

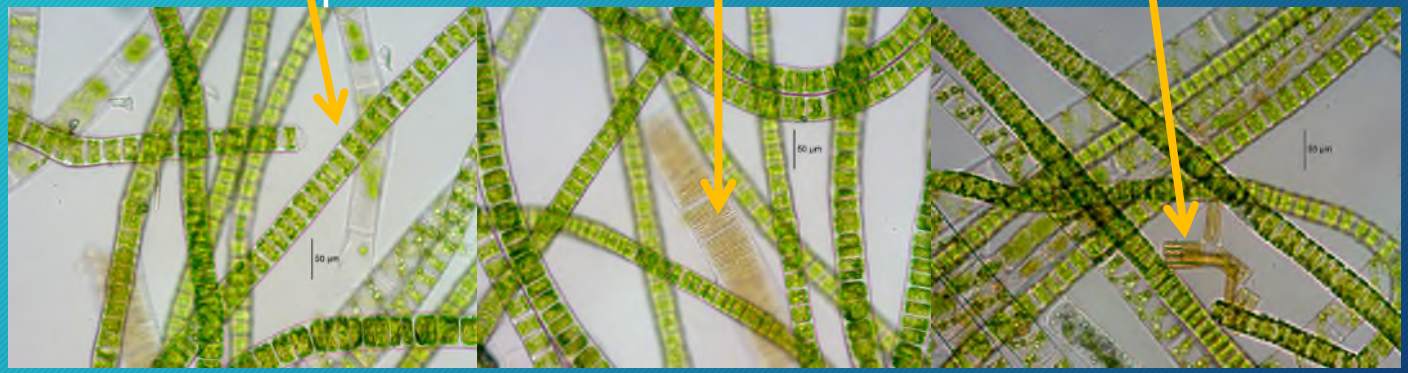
Gloeotrichia – 40x

Comparing field scope with laboratory scope

iPhone Field Scope



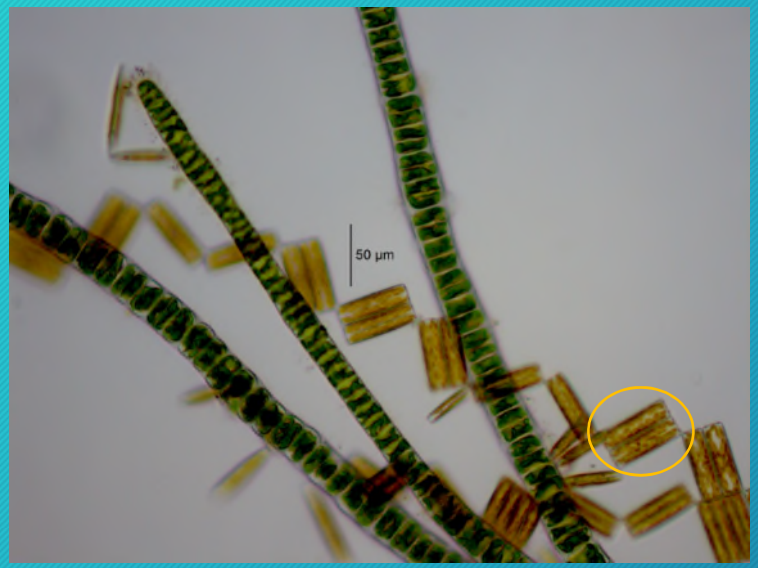
Leica Lab Scope



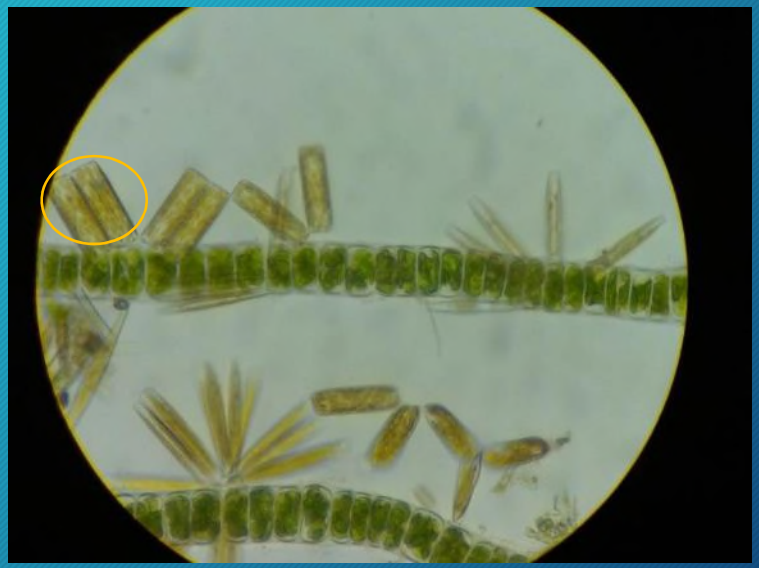
Ulothrix, *Spirogyra*, diatoms – 200x

Comparing field scope with laboratory scope

Leica Lab Scope

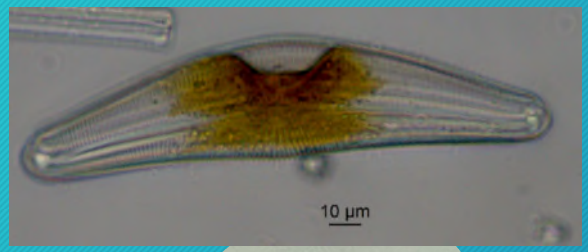


iPhone Field Scope



Ulothrix, *Diatoma vulgaris* – 200x

Comparing field scope with laboratory scope



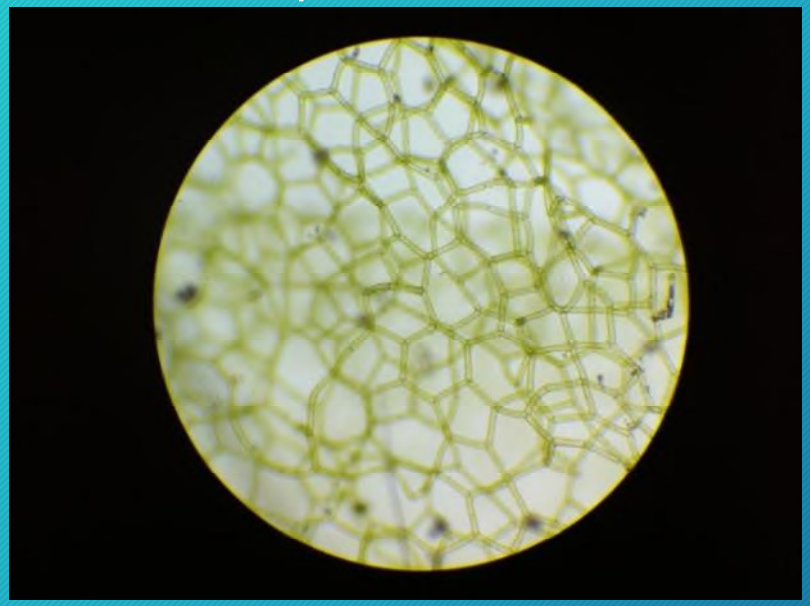
Leica Lab scope – 400 x

iPhone Field scope – 200 x
(and digitally zoomed)

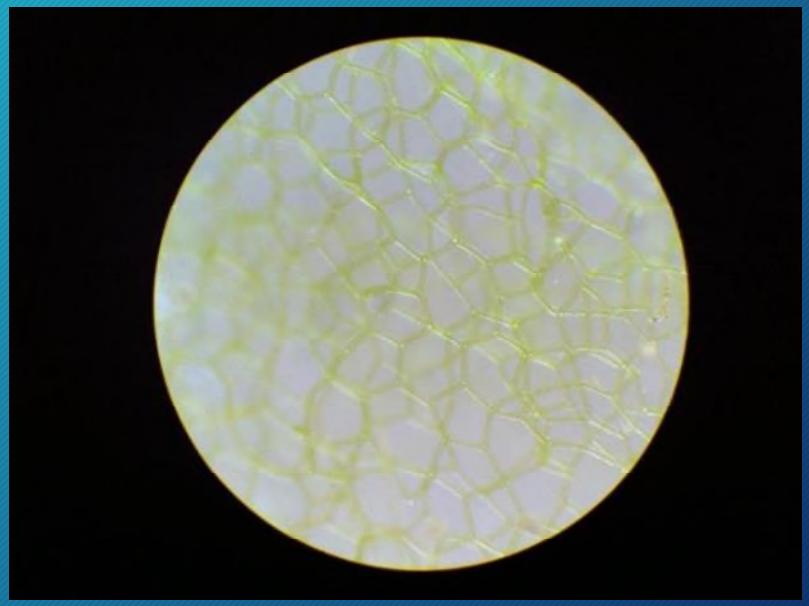
Cymbella

Different lighting strategies offer different perspectives

Overhead → better detail of fine, superficial features



Oblique → better concept of 3-D structure



Hydrodyction – 40x

Cell phone movie capability is useful for identifying motile taxa

Euglenoids

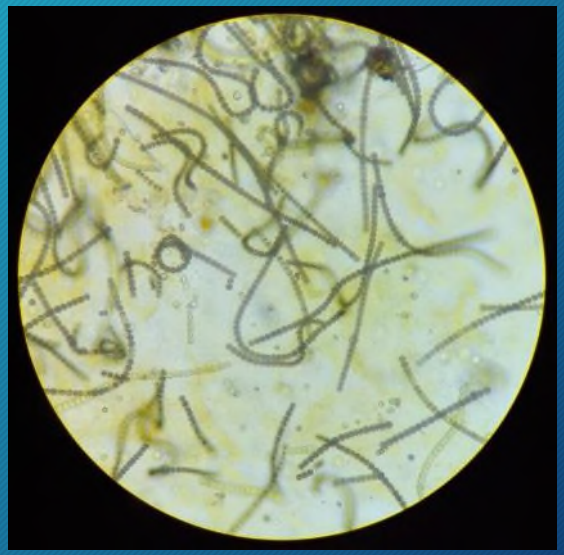
Pros

- Highly portable (light, small) easy to use
- Can assess specimens directly in field without need for preservation
  - avoids transporting/handling of toxic substances
  - Avoids deforming/distorting important diagnostic features, such as fine structural details and pigment color, by fixative (or rotting/fungal infestation of unfixed sample)
  - Recording video of live specimens in motion. Useful for IDs (e.g., Euglenoids)
- Variable lighting options afford different types of imaging

Chara - 40x – in Sedgewick-Rafter cell with oblique illumination – iPhone Field Scope

Cons

- Images not as crisp as on lab scope; more washed-out (due in part to more diffuse lighting?)
- Very difficult to make fine adjustments to the positioning of microscope slide, especially at high power (> 40x)
- No built-in means for measuring specimen dimensions



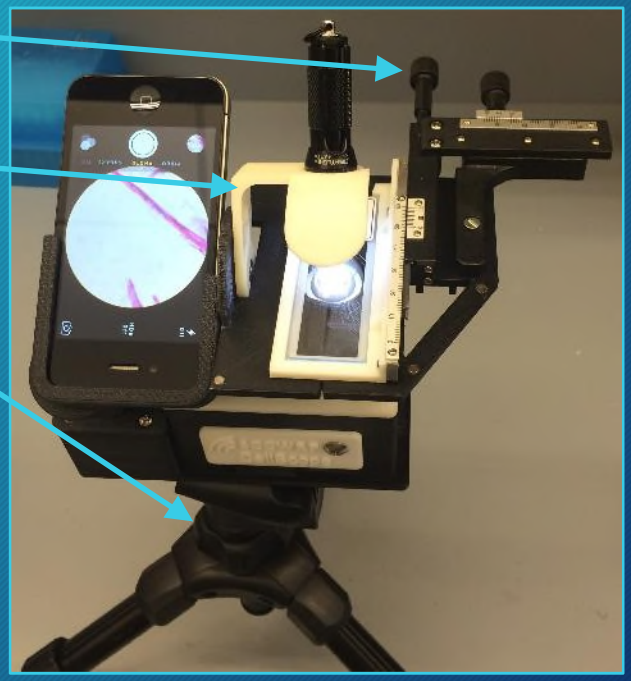
Nostoc - 200x – iPhone Field Scope

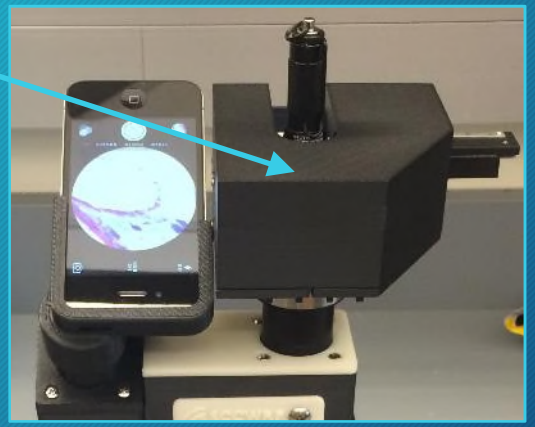
Improving on the CellScope

- Improved/mechanical control of stage
- Better lighting control
- Android and iPhone support
- Embedded scale bar (or software scale bar)
- Field-friendly configuration (e.g. enclosed stage)
- Improved 3-D imaging?

CellScope updates (SCCWRP model)

- X-Y slide translation mechanism
- Magnetic stops on the light source for defined illumination positions
- Tripod mount
- Enclosure for sample to permit darkfield in bright conditions
- Mounts for Nexus 4 and 5 and iPhone 5





What next?

- There is significant interest in potential applications for the CellScope
  - Regional and Statewide monitoring programs
  - A tool for use by Citizen Scientists
  - Incorporation into developing methods and protocols for bioassessment

What next?

- Integrate images with mobile field apps for comprehensive data collection
  - Does this sample make sense (given location/other data collected at the site)?
  - Should samples be brought back to lab?

What next?
(Real-time: the "dream" solution)

- Tie back to existing image libraries and/or image analysis for in field ID
  - Provide an "expert system" to the user in the field
- Integrate records with field and sensor data
  - Link to calculation of indices used to provide site scores for bioassessment

Moving CellScope forward

- A new application (environmental monitoring) and interested user community
  - Scientists who are knowledgeable in the biology, methods and technology to link these tools to real-world applications
  - Access to and trust of key players (agencies, scientists, educators) at the state and National levels
- Ability to assist in development/testing in a new application area

Thank You
Questions?

Steven J. Steinberg, Ph.D., GISP

Principal Scientist – Information Management & Analysis

Southern California Coastal Water Research Project

steves@sccwrp.org

714-755-3260

www.sccwrp.org